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# Modeling and Control of Power Converter for Doubly Fed Induction Generator Wind Turbines using Soft Computing Techniques

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**Abstract:**
This paper is based on Fuzzy Logic Controller (FLC) Control of Doubly Fed Induction Generator (DFIG) wind turbine in a power system for nonlinear loads. By which the nonlinear system can be made to work as a linear system to bring out better performance. . Fuzzy logic is a logical system which provides definite solution to solve problems. It process with fuzzy variables which are defined by membership functions. The combined action of PI and FLC controls the switching actions, distortion in harmonics and provide compensation for unbalanced load if any at the point of common coupling. The proposed system consists of back to back connected converters, one is connected to the generator side and the other is connected to the grid side. The grid side connected converter is used for compensation ie, it act as an Active Power Filter (APF) and compensator hence the cost of using APF is reduced. Reduced Total Harmonic Distortion (THD) is obtained by simulating (MATLAB/SIMULINK) the performance and the result is found to be quite satisfactory.

**Key Words:** Fuzzy Logic Controller, Harmonic Reduction, Power converter, Renewable Energy.

## 1. INTRODUCTION

The emission of fossil fuels has increased the effect of global warming and ozone depletion. To mitigate this effect power can be generated from various renewable resources. Wind energy is one of the most economic sources of energy for the production of electricity. Wind energy is economically viable renewable energy source today. The machine which is used to convert kinetic energy in the wind to electrical energy is called as wind turbine. In electrical power systems power quality distortion has become a serious problem due to the increase in number of nonlinear loads. As the number of nonlinear loads increased, harmonics current is more significant generated by these loads. These harmonics can lead different power system problems like distorted voltage waveforms, malfunction in system protection, excessive currents, light flicker, overheating of equipment. To mitigate the harmonic distortions, unbalanced voltage, voltage flickering, active power compensation, reactive power compensation and transient conditions Active Power Filters are used which leads to more complexity of the system and increased cost.

Inspite of many control techniques Fuzzy Logic is a control system which is based on certain logical functions and nearer to human thinking process. The advantage of Fuzzy Logic Controller over other controller is it does not require mathematical model unlike other controllers used for linear systems. It can handle nonlinearity and can be of more robust. When compared to PI controllers Fuzzy Logic system is more efficient for nonlinear networks i.e., it minimizes harmonics and improves the quality of power. Adaptiveness cannot be achieved in the operation of fuzzy logic. Difficulties in tuning the PI and NFC can be achieved by using NFC which act as a tuned estimator. The proposed system is implemented with Variable Speed Wind Turbine (VSWT) which is more contrast than constant speed wind turbine as the power extraction is less when compared to variable speed wind turbine, so the power

fluctuations can be avoided also maximum power can be obtained at variable speed condition. WECS is connected directly to the grid and hence the power supply to the grid must be of balanced one as the grid should be maintained at unity power factor, hence to provide grid synchronization. The use of Doubly Fed Induction Generator is more advantage as the supply to the AC mains can be from both stator and rotor as the stator is connected to the AC mains whereas rotor is connected to the control system which may be of PI and NFC. Normally PI controllers are suitable for linear systems where as FLC is for nonlinear systems even though the distortion in harmonics is reduced for both linear and nonlinear network by PI and FL controllers, the output of which is not much efficient when compared to NF controller, which can be seen while comparing FL and NF controllers.
Figure 1 shows the block diagram of WECS, which consist of VSWT, DFIG, interconnections and FL controller. IGBT is utilized as interconnections to control the power at unbalanced conditions. The converter which is connected at the grid side is used for the compensation of real and reactive power flow hence the cost of using APF is reduced. The power control is mainly done by power converters (IGBT). The switching loses obtained due to power converters are controlled by Fuzzy Logic Controllers.

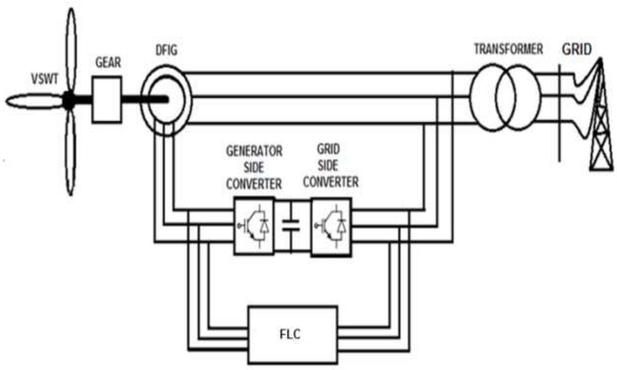


Figure 1. Block diagram of WECS

## 2. DFIG WIND TURBINE

Recently Doubly Fed Induction Generators are widely used in WECS because it is more suitable for the operation under variable speed condition. The configuration of DFIG is shown in figure 1. In which the fast rotation of the DFIG wind turbine is obtained as it is coupled with gearbox, which converts the slow rotation of the wind turbine into fast rotation. Bothe the stator and rotor present in DFIG is connected to the AC mains and hence the power can be injected to the grid by means of both stator and rotor. Stator is directly connected to the grid whereas rotor is connected to the power converter (IGBT) which in turn connected to the grid. The advantage of using DFIG is it extracts maximum power even at low wind speed by optimizing the wind turbine speed.

## 3. SYSTEM IMPACT

In normal system impacts are those which affect the performance of the system as a whole. It mainly depends on wind power penetration level in the system. Stability, system dynamics, reactive power control, voltage control and frequency control are the certain impacts on the power system. The voltage instability is mainly due to flicker which causes voltage flickering. At any fault conditions acceleration takes place between the mechanical power extracted from the wind and electrical power supplied to the grid. When the voltage restores more amount of reactive power is consumed. The higher the wind power penetration, the increase in impacts on power system. To control these impacts we go for controlling techniques both for linear and nonlinear systems. For linear systems PI controllers are more suitable and for nonlinear network system Fuzzy Logic Controller is implemented to control under variable speed and nonlinear loads.

 

## 4. FUZZY LOGIC CONTROL

Fuzzy Logic is based on logical functions. The concept of Fuzzy logic is derived from set theory. There are several controllers which provide efficient control for linear systems. In case of nonlinear systems Fuzzy Logic Controllers are used. Fuzzification, rule creation, and defuzzification are the steps involved in fuzzy logic system. The input to the fuzzy controller is in the form of real variables. In the process of fuzzification the real variables are converter into fuzzy variable and each fuzzy variable are represented by membership function. The second step is formation of fuzzy rules, fuzzy rules are based on definite decision i.e., in the form of IF-THEN. Finally when all the operations of control is over at the last stage the fuzzy variables are again converted into real variables which is as known defuzzification.

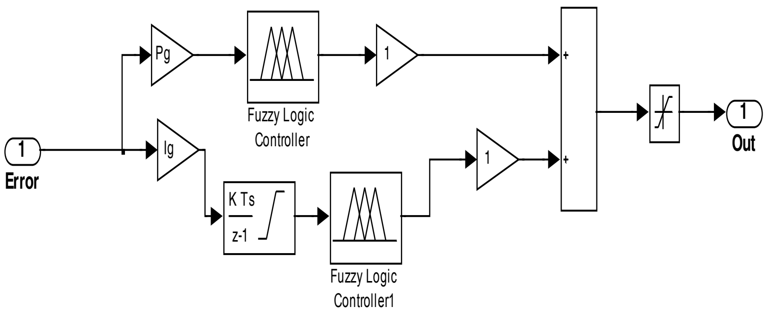


Figure 2. Fuzzy logic controller

## 5. SIMULATION RESULT AND DISCUSSION

The figure 3 shows the simulation block diagram for the proposed system. To obtain the performance of the system measurements are carried out. By variable speed and by varying the load Total Harmonic Distortion (THD) is evaluated.

 

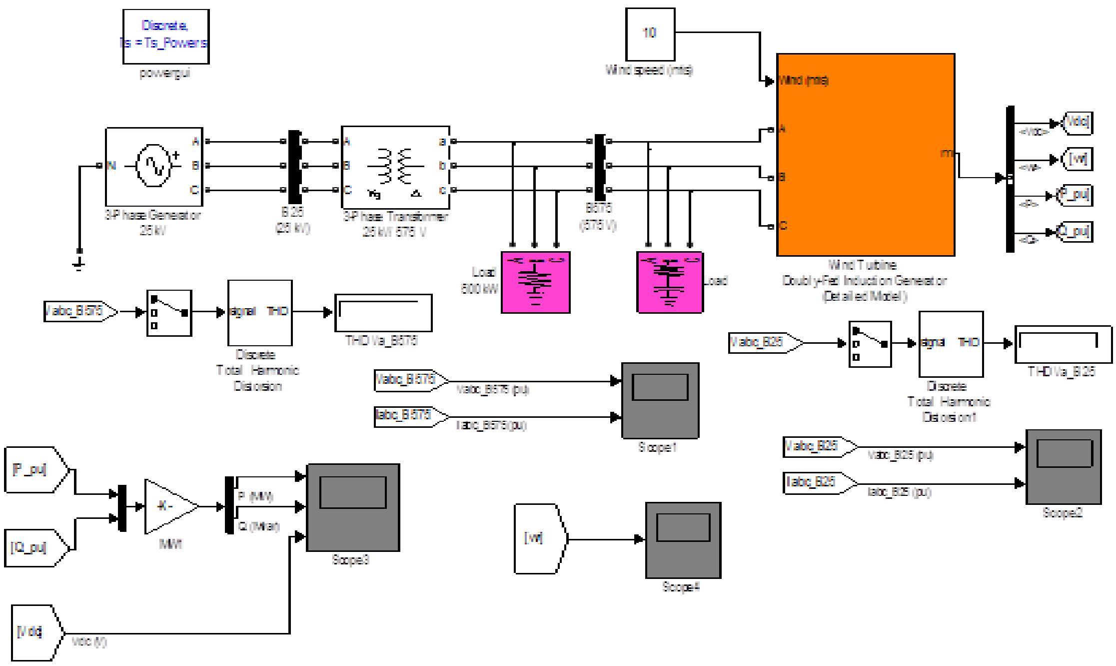


Fig: 3 Simulation block diagram

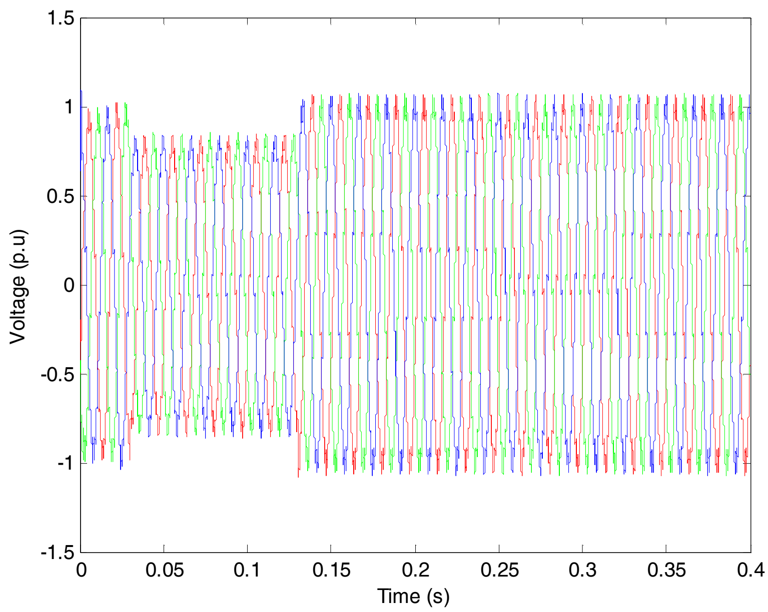


Figure 4. Voltage chracteristics

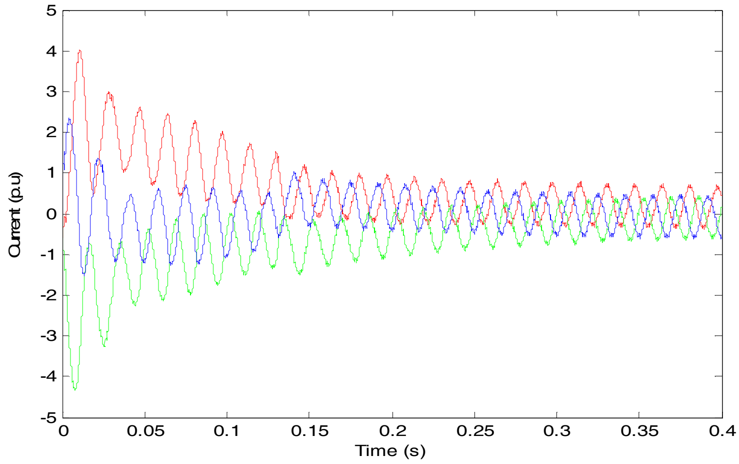


Figure 5. Current characteristics

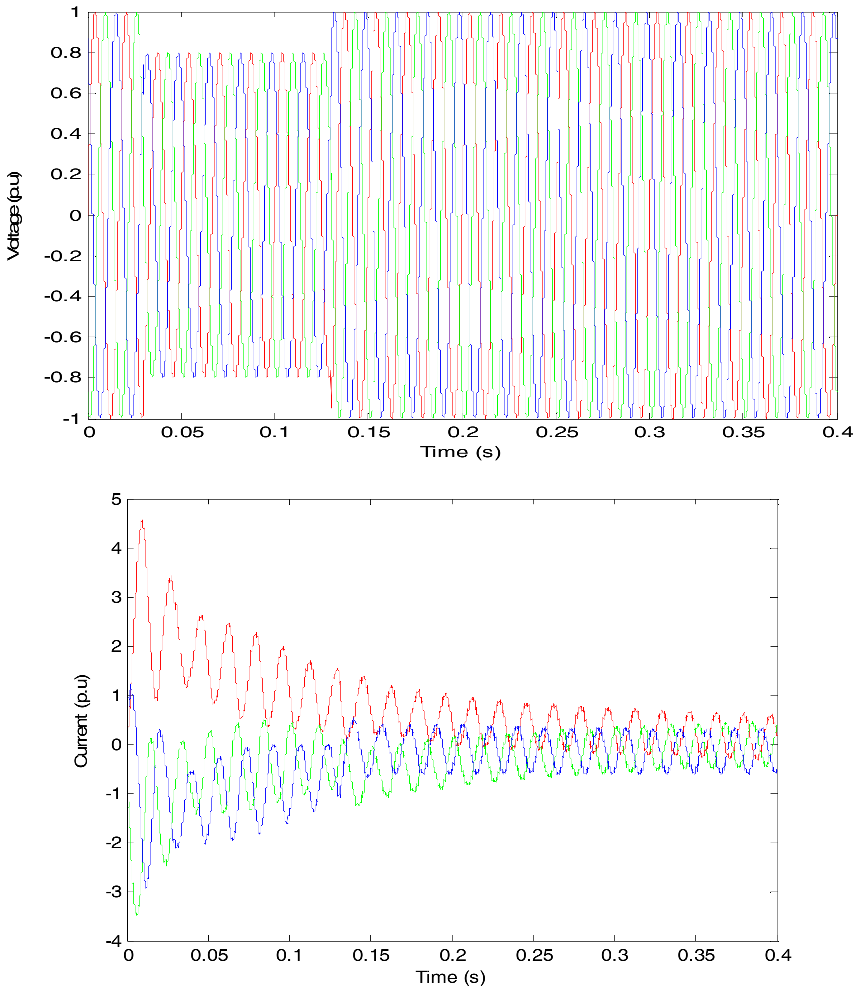


Figure 6. 575V Voltage and current relationship

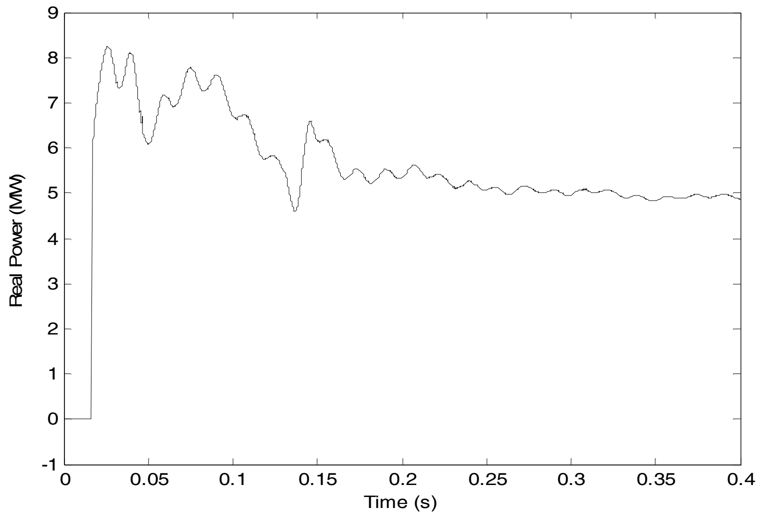


Figure 7. Real power of asynchronous machine

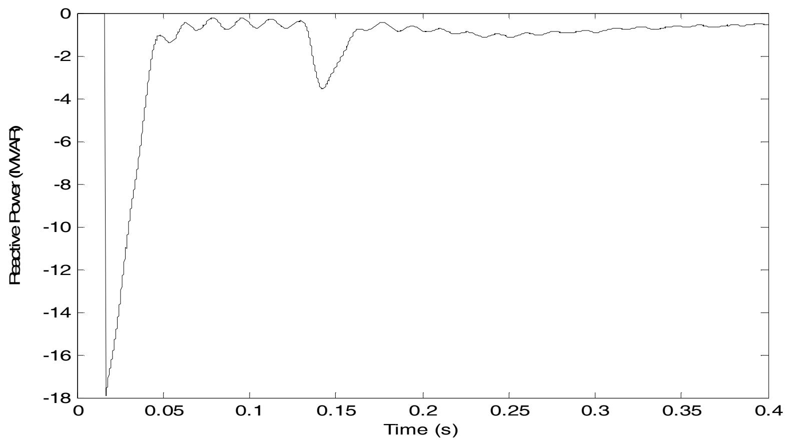


Figure 8. Reactive power of asynchronous machine

 

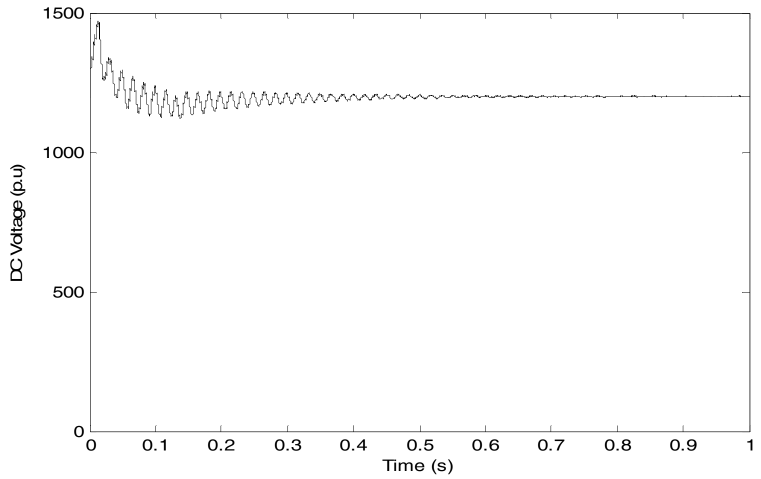


Figure 9. Voltage in common DC link

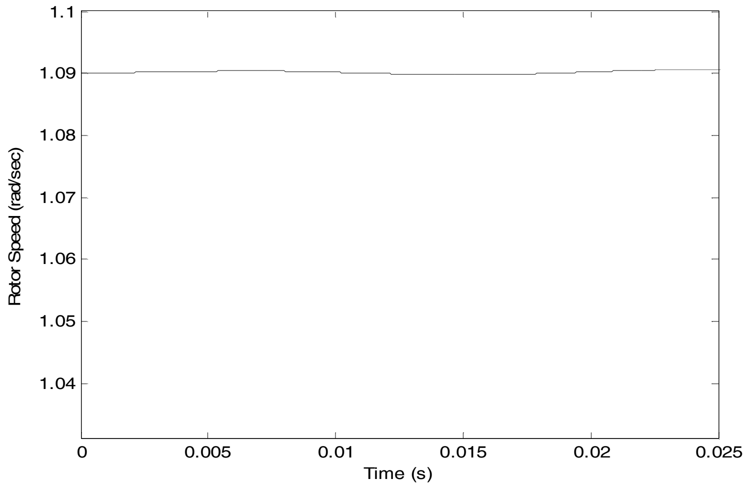


Figure 10. Rotor speed curve characteristics

The figure shows the result of scope 1, ie, voltage Vs time graph of 25KV bus in which the FLC eliminates detects the error and eliminates it. The next fig: shows current Vs time plotted for 25KV bus. In this the three phase current are in different phases in the beginning due to harmonics, further which ii is eliminated.The graph is plotted for time t=0.4sec, by the time t=1sec it will become stable.offering no harmonics. The figures shows the result for scope 2, in this we have voltage Vs time graph plotted for 575volt and current vs time for 575volt. Fig: shows the real power curve of asynchronous machine, within a time period of disturbances made in the system will be handled by the fuzzy logic controller, by the time period t=0.5 it will attain a stability mode, ie, without any errors in the system. The real power is measured in MW. In fig: reactive power of asynchronous machine is calculated. In this there will be a point when the reactive power falls at zero due to harmonics present in the system. This rectification will be done by the fuzzy logic control by eliminating the errors and producing a stable graph. The fig: shows the voltage present in the common dc link. By considering this as error signal and comparing with reference signal we produce firing to the inverter block. Fig: describes about the rotor speed of the induction machine. In this we can see that the rotor speed is made constant with slight variations during the disturbances which are handled by the fuzzy logic system.

## 6. CONCLUSION

The basic operation of DFIG and its controls using AC/DC/AC converter. . First a wind turbine driven isolated (not connected to grid) induction generator is simulated. But for better efficiency DFIG is used which is connected to the grid and also have good controlling capability. Normally the real power and reactive power control is obtained by the Rotor Side Converter (RSC) and the voltage is maintained constant by the Grid Side Converter (GSC). The model is a discrete-time version of the Wind Turbine Doubly-Fed Induction Generator (Phasor Type) of Matlab / Sim Power Systems. Protection system in considered which gives a trip signal to the system when there is a fault (single phase to ground fault) on the system. The faults can occur when wind speed decreases to a low value or it has persistent fluctuations. The DFIG is able to provide a considerable contribution to grid voltage support during short circuit periods. From the results it can be said that doubly fed induction generator proved to be more reliable and stable system when connected to grid side with the proper converter Fuzzy control systems.

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